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SHORTEST PATH FINDING IN GEOGRAPHICAL INFORMATION SYSTEMS USING NODE COMBINATION AND DIJKSTRA ALGORITHM

Achmad Fitro
Politeknik NSC Surabaya and Student at Master Program of Information System, School of Postgraduate, Diponegoro University, Semarang

Otong Saeful Bachri*, Arif Ilham Sulistio Purnomo, Indra Frendianata
Computer Science Polytechnic Cirebon (STIKOM PolTek Cirebon)
Jl. Brigjend Darsono No. 33, Kedawung, Cirebon, West Java 45153, Indonesia
*Corresponding author

ABSTRACT

The problem of finding the shortest route as one of the fundamental case studies in the field of computer science is quite challenging, especially if it involves large variables. Manual calculations will be difficult to obtain optimal solutions in a short time, even just for one destination. In this article, we discussed a combination of node combination algorithms and Dijkstra algorithm to find the shortest path from one point to another on Geographic Information Systems (GIS) based systems. This combination allows the use of memory during the route search process can be reduced, in addition to the solution obtained can be ascertained is the optimal solution with the shortest route. The data used in this research is obtained from the map location in Taman Subdistrict, Sidoarjo, East Java, Indonesia, with the number of nodes as many as 17 pieces and 72 vertices. Distance spacing is calculated based on the value of latitude and longitude obtained from the Google Maps API.

Keywords: shortest route search, node combination, Dijkstra, Geographic Information System.

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1. INTRODUCTION

Geographic Information System (GIS) is a special information system based on data related to geographic coordinates (longitude, latitude) that aims to assist decision-making or policies related to geographical information in a region [1]. The rapid development of GIS applications has increased the effectiveness of the use of geographic information in real time across a wide range of disciplines [2].

One of the key points of GIS implementation is to find the shortest route of travel from one point to another (shortest path finding). Dijkstra's algorithm is one of the most popular techniques that have been widely used by researchers to solve the problem. Some examples of its implementation include finding the shortest transport route to save fuel and time [2-4], searching for the shortest evacuation route [5], finding a route to the nearest parking lot [6], and assisting construction workers to organize exit routes -including vehicle carrier materials to minimize the risk of accidents and accelerate the distribution of building materials [7].

However, Dijkstra's algorithm does not handle memory usage, so Dijkstra's algorithm will use large memory space to store the points passed over each iteration when searching for the shortest route from a very large graph. Therefore, this article aims to present the search technique with a combination of node combination algorithm with Dijkstra algorithm to produce the shortest route search system that is not only optimal but also capable of providing efficiency from the aspect of memory usage. The use of this node combination algorithm allows memory savings on each iteration by combining the nodes with the smallest distance into a single node.

2. DATA

The object of the research was conducted at Taman Subdistrict, Sidoarjo Regency, East Java, Indonesia by taking 17 important interconnected nodes forming a graph with 72 vertices as shown in Figure 1. Each node has latitude and longitude coordinates obtained through Google Maps API, where the latitude values are in the range [-7.3512, -7.3418] and longitude [112.689, 112.7028]. The average degree of connectedness of each node in the graph is 4 to 5 relationships.

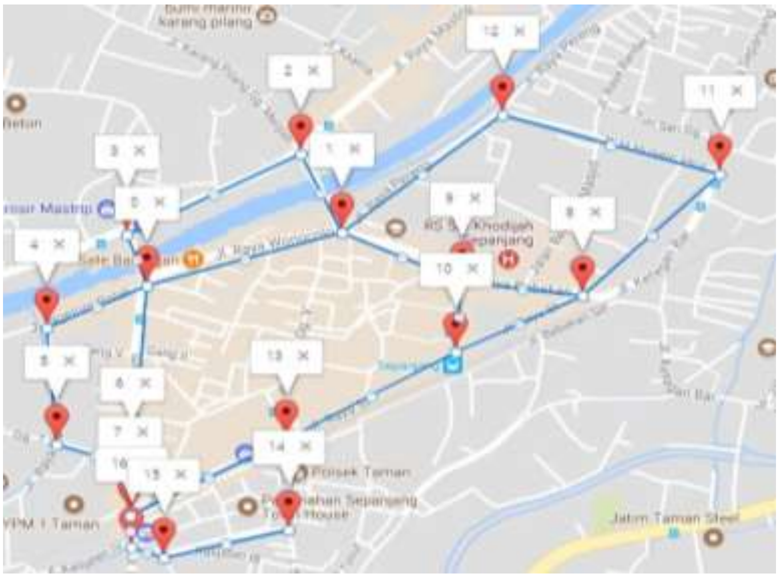

Figure 1 Graph that connects 17 nodes in Taman Subdistrict, Sidoarjo, East Java, Indonesia.

3. METHOD

3.1. Dijkstra's Algorithm

Dijkstra's algorithm is a very popular short-haul search technique, especially among researchers in Mathematics or Computer Science. The algorithm proposed by Edger Dijkstra in 1959 was able to work effectively to find the optimal path that has the least weight from one point to the destination point [3]. This algorithm accepts the input of a G graph that has weights between two interconnected nodes, an initial node, and a final node that is the destination of the route search. Even Dijkstra's algorithm is claimed to be able to find solutions faster than some other algorithms such as A * (A star) and Ant Colony Algorithm [8]. With the algorithm as shown in Table 1, Dijkstra Algorithm will always succeed in finding the shortest route from the initial node to the final node.

Table 1 Pseudo code Dijkstra Algorithm

Dijkstra Algorithm

```
Set adjacency matrix from graph G
s = start node
g = goal node
bestnode = s

while bestnode ? g
     for all successors of bestnode do
        calculate the distance from s to these successors
     end for

     best_successor = successor with minimum distance from s
     change bestnode with this current best_successor
end while
```

3.2. Node Combination Algorithm

The node combination algorithm basically merges the two nodes that have the closest distance (expressed by the vertex weights between the two) [9]. As shown in Figure 2, node 1 has the smallest distance to node 2, so node 1 and node 2 are merged into one. After that, the successor of node 2 (ie node 5) becomes connected directly to node 1. The systematic steps of the combination node algorithm can be seen through the pseudo code presented in Table 2.

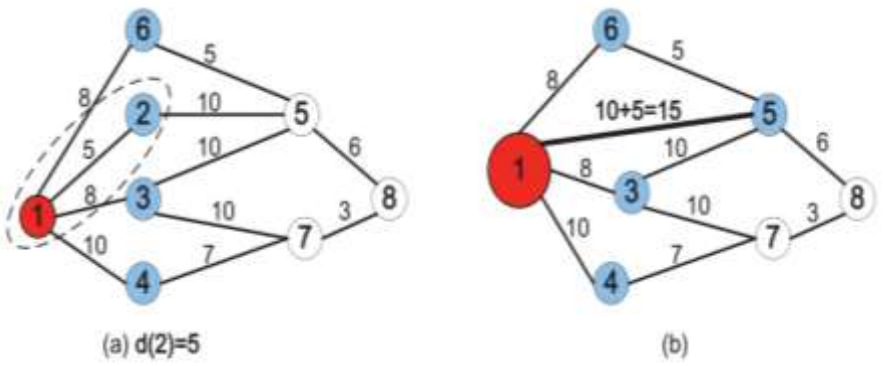

Figure 2 Illustration of the merging process of two nodes having the smallest distance [9]

Table 2 Pseudo code of Node Combination Algorithm

Node Combination Algorithm

```
Set adjacency matrix from graph G
s = start node
g = goal node

while s ? g
     for all successors of s do
        calculate the distance from s to these successors
     end for

     best_successor = successor with minimum distance from s
     succ_best_successor = successor of best_successor
     combine s with best_successor
     connect s to succ_best_successor
     update distance from s to succ_best_successor
end while
```

4. RESULTS AND DISCUSSION

The built system is tested by determining the shortest path search from the starting point to the end point. In this test scenario, it is assumed that the starting point is the 11th node, while the end point is two, ie the 3rd and 10th nodes. Test results are presented in Table 3.

Table 3 The shortest route result from the 11th node to the 3rd node and the 10th node

Path	Start	Destination	Route	Distance
Route 1	L	D	11 – 12 – 1 – 0 – 3	1482 metre
			11 – 12 – 1 – 2 – 3	1540 metre
			11 – 8 – 9 – 1 – 2 – 3	1564 metre
			11 – 8 – 9 – 1 – 0 – 3	1506 metre
Route 2	L	K	11 – 8 – 10	708 metre

Route search results presented in Table 3 show that combinations of combined node algorithms and Dijkstra's algorithm find the path with the shortest route from the starting point to the end point. Moreover, with a little mathematical calculation, the travel time from the starting point to the end point can also be obtained as presented in Table 4 (assuming that the average velocity is 40 km/h).

Table 4 Route search results with the shortest travel time from the 11th node to the 3rd node and the 10th node

Path	Start	Destination	Route	Time
Route 1	11	3	11 – 12 – 1 – 0 – 3	2 m 14 s
			11 – 12 – 1 – 2 – 3	2 m 19 s
			11 – 8 – 9 – 1 – 2 – 3	2 m 20 s
			11 – 8 – 9 – 1 – 0 – 3	2 m 15 s
Route 2	11	10	11 – 8 – 10	1 m 4 s

5. CONCLUSIONS

This article presents the problem-solving technique in the shortest path search based on Geographic Information Systems using combination of methods that are node combination algorithm and Dijkstra algorithm. Based on the results of tests that have been done, the technique succeeded in finding the optimal route in the case study route in Taman Sub district, Sidoarjo Regency, East Java, Indonesia. The results presented can be the distance traveled or travel time from the starting point to the end point. The results show that the route 1 from L point to K is the shortest route, connecting the points 11 - 8 - 10 as far as 708 metres. Moreover, on searching of route with the shortest travel time from the 11th node to the 3rd node and the 10th node, the results show that route 2 starting from point 11 and ending at point 10 by connecting 3 points 11-8-10 has the shortest distance, ie only 1 m 4 s.

REFERENCE

[1] Rodriguez-Puente, R., Lazo-Cortes, M. (2013). Algorithm for Shortest Path Search in Geographic Information Systems by using Reduced Graphs. Springer Plus, 2 (291), 1-13.

[2] Alazab, A., Venkatraman, S., Abawajy, J., Alazab, M. (2011). An Optimal Transportation Routing Approach using GIS-based Dynamic Traffic Flows. Int'l. Conf. on Info. And Financial Eng., 172 – 178.

[3] Haixiang, D. and Jingjing, T. (2013). The Improved Shortest Path Algorithm and Its Application in Campus Geographic Information Systems. Journal of Convergence Information Technology, 8(2). doi: 10.4156/jcit. vol 8. issue 2.5

[4] Amaliah, B., Fatichah, C., and Riptianingdyah, O. (2016). Finding the Shortest Paths among Cities in Java Island using Node Combination based on Dijkstra Algorithm. Int'l Journal on Smart Sensing and Intellligent Systems, 9(4), 2219-2236.

[5] Miller, M., Medak, D., Odobasic, D. (2013). The Shortest Path Algorithm Performance Comparison in Graph and Relational Database on a Transportation Network. Information and Communication Technology Preliminari Communication, 26(1), 75-82.

[6] Jaafar, H., Zabidi, M.H., Soh, A.C., Hoong, T.P., Shafie, S., and Ahmad, S.A. (2014). Intelligent Guidance Parking System using Modified Dijkstra Algorithm. Journal of Science and Technology, 132-141.

[7] Solthani, A.R., Tawfik, J.Y., Goulermas, Fernando, T. (2002). Path Planning in Construction Sites: Performance Evaluation of the Dijkstra, A*, and GA search algorithm, Advanced engineering informatics 16, 291-303.

[8] Choubey, N., Bhupesh, and Gupta, K.R. (2013). Analysis of Working of Dijkstra and A* to Obtain Optimal Path. International Journal of Computer Science and Management Research, 2(3).

[9] Lu, X., and Camitz, M. (2011). Finding the Shortest Paths by Node Combination. Applied Mathematics and Computation, 217, 6401-6408. doi: 10.1016/j.amc.2011.01.019.

[10] Wahyuni, S., & Ginting, M. (2017). The Impact of Product Quality, Price, and Distribution on Purchasing Decision on the Astra Motor Products in Jakarta. Arthatama: Journal of Business Management and Accounting, 1(1), 18.

[11] Kurniawan, R. (2017). Effect of Environmental Performance on Environmental Disclosures of Manufacturing, Mining and Plantation Companies Listed in Indonesia Stock Exchange. Arthatama:Journal of Business Management and Accounting 1(1), 6-17.

[12] Y. Yaswanth Kumar, D.V. Satyanarayana Moorthy and G. Shanmuka Srinivas, Identification of Groundwater Potential Zones Using Remote Sensing and Geographical Information System. International Journal of Civil Engineering and Technology, 8(3), 2017, pp. 01–10.

[13] SS. Asadi, Abel Dungana and Paras Mani Ghalley, Remote Sensing and Gis Based Critical Evalution of Water Balance Study from Woochu Watershed, Bhutan, International Journal of Mechanical Engineering and Technology 8(10), 2017, pp. 434–447.

[14] Kallakunta Ravi Kumar, SS. Asadi and Venkata Ratnam Kolluru, Remote Sensing and Gis Based Land Utilization Analysis: A Model Study from Vamsadhara River Basin, International Journal of Mechanical Engineering and Technology 8(11), 2017, pp. 866–873.